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JOHNSVILLE, PENNSYLVANIA

Aviation Medical Acceleration Laboratory

Investigation of X-Radiation Hazard from AN/APS-20E Radar; letter report concerning

Bureau of Aeronautics
ADC-AV-34040.1

U. S. NAVAL AIR DEVELOPMENT CENTER
JOHNSVILLE, PENNSYLVANIA

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From: Commanding Officer, U. S. Naval Air Development Center
To: Chief, Bureau of Aeronautics (AV-3320)

Subj: ADC-AV-34040.1, Investigation of X-Radiation Hazard from AN/APS-20E Radar; letter report concerning

Ref: (a) NADC ltr AEEL to BuAer (AV-3320) of 17 January 1958
(b) Preliminary Radiological Survey, Health Physics Staff Report AN/APS-20E, Naval Research Laboratory, Washington, D. C. April 1958.
(c) R. Zendle and E.E. Goodale. Some Unusual Radiation Dosimetry Problems Associated with Radar Installations, General Electric Report 58GL242, August 19, 1958.
(d) P. Order, RADC-TN-56-278 PB 121955 (1957), Rome Air Development Center, Griffiss Air Force Base, New York.
(e) W. G. Egan, Electronic Design, March 195, 1958.
(f) R. Zendle and E.E. Goodale, Some Unusual Radiation Dosimetry Problems Associated with Radar Installations, General Electric Co., Health Physics, Vol. 2, p. 80, note (1959)
(g) Investigation of 4J52 and 4J50 Magnetrons for Possible X-Ray Emission, NADC-AEEL, Johnsville, Pa.
(h) E.A. Wolicki, R. Jastrow and F. Brooks, Calculated Efficiencies of NaI crystals, Naval Research Laboratory, Washington, D. C., USA NRL-4833, August 27, 1956.

1. In conducting a radiological survey of radar installations, one is confronted with some rather unusual measurement problems. There are two types of electromagnetic radiation generated simultaneously; one is microwave (rf) radiation that the transmitter is designed to generate and the other is x-radiation originating from high energy electrons striking any material that is in their path. It has been found that the rf which the radar produces has a considerable effect upon the electronic circuits conventionally used for the measurement of x-radiation. The ordinary ion chamber radiation survey equipment is subject to serious errors, becoming inoperative in most cases, when used near operating radar equipment, references (a to g).

2. It has been found feasible to shield conventional commercial radiological survey instruments, including any external probes and cables, to reduce rf pickup to an acceptable level. At this laboratory a conventional "Cutie Pie"

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has been used in two configurations. In one it was enclosed in a solid metal box with wave guides designed to cut off, serving as ports through which the x-rays could get in and also serving as a means which would allow reading of the meter. In the other, it was enclosed in a copper mesh screen. Neither of these arrangements has proved entirely satisfactory, since the mesh screening introduces energy dependence and reduced efficiency (c). The boxed "Cutie Pie" is unwieldy, difficult to read (requiring a light inside the box), and is sensitive to only unidirectional x-rays that pass through the wave guides. An even more serious consideration is that magnetrons produce x-rays only during a small percentage of the operating time. The nature of the radar requires maximum pulse intensity and minimum pulse duration. During a pulse the ionization chamber could be subjected to a level as high as 200,000 r/hr (f).

3. The question arises as to the ability of an ionization chamber to integrate properly this amount of low energy (10 KVP to 150 KVP) radiation. Ion recombination is almost certain to occur. Likewise, space charge will have an effect. The question of maintaining potential across the chamber arises, since considerable pulse current will flow. Theoretical and experimental determinations have been made by Zendle and Goodale of the expected losses measuring pulsed radiation of this nature, reference (f).

4. Film is not satisfactory as a dosimeter for these low energies because of the halide resonance in the emulsion. In addition, rf affects film to some degree. The film packets which were used in this laboratory were wrapped in aluminum foil to shield the rf. DuPont 550 film packets have been used. All have been affected. These packets are slightly sensitive to microwaves. Kodak medical no-screen x-ray is least affected.

5. An attempt to solve the problem of the pulsed radiation has been made by using a scintillation detector. An inorganic crystal such as NaI (th) gives a light output proportional to the energy of the particle or photon when the whole range of the particle is contained in the crystal. From this it follows that light yield is proportional to ionization (h). A 1/4 inch x 1 3/4 inch sodium iodide crystal with a one mill Al covering was mounted on a Dumont 6292 photomultiplier. The maximum current ratings for this tube are peak anode current of 25 ma and peak cathode current of 20 microamps. Calculations indicate that this tube will not saturate at the peak light

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intensities expected from the crystal. Peak r intensities would be efficiently converted to light by the crystal. It is not necessary to resolve the light pulses due to individual photons. In this trial the crystal was mounted on a portable LaRoe scintillation rate meter. This particular instrument seemed to be well shielded against pickup of microwave energy. A MUMETAL magnetic shield was used around the photomultiplier.

6. The instrument was calibrated using a 9 mc radium source. The 1/4 inch thick dimension of the crystal was chosen so that any ionization produced by a photon having an energy greater than approximately 60 KV would not be totally absorbed within the crystal. Thus, photons of energy greater than 60 KV could be expected to give an output of approximately a 60 KV pulse, enabling one to calibrate more accurately for low energy photons, using an isotopic source such as radium.

7. Two diverging beams of x-rays were found to be emanating from the side of the magnetron at an approximate angle of 30 degrees from the horizontal and about 30 degrees apart. The intensity was approximately .035 mr/hr at 4 inches from the tube. No x-radiation was found to originate in the power supply, as had been found on other radars, reference (a).

8. In order to determine the energy of the emitted x-ray, a Baird Atomic Single Channel Pulse Height Analyzer system was used, which included the 1/4 inch x 1 3/4 inch sodium iodide. The output of the radar was fed into a dummy load to eliminate rf pickup as much as possible. In order to obtain maximum energy sensitivity for low energies the gain on the amplifier was set very high. Since Cesium 137 peaks at 32 KV, it was used to calibrate the baseline reading of the pulse height analyzer. A Ba 133 source was used for checking the Cesium peak. (Both have characteristic 32 KV x-rays). The noise problem was substantial when a Fe 55 source (5.9 KV) was used, and the peak could not be distinguished from the noise. The energy of the emitted x-radiation was determined to be a line at 30 KV. The width of the line was approximately 5 KV; it could not be resolved from the 32 KV Cesium peak.

9. The x-rays emitted from the magnetron are very similar to the characteristic Barium or Cesium x-rays. It is concluded that these x-rays result from electron bombardment of Barium or Cesium, both of which compose

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parts of the magnetron. Both Barium and Cesium have been used as activators for the cathode and as getters to remove residual gases.

10. This report was prepared by John Taylor of the Health Physics Division and approved by Dr. James D. Hardy, Research Director, Aviation Medical Acceleration Laboratory.

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By direction